Renewable and Sustainable Energy Reviews 13 (2009) 2728–2733

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Subsidy policy and the enlargement of choice☆

Sunderasan Srinivasan [1,*]

Economist, Verdurous Solutions Private Limited, Mysore, India

ARTICLE INFO

Article history:
Received 23 January 2009
Accepted 9 June 2009

Keywords:
Incentive structures
Choice enlargement
Solar energy systems

ABSTRACT

Development is the enlargement of people's choices. Optimal subsidy policy is intended to create the right incentives for each of the value chain participants. This paper contends that the interest subsidy offered by the Indian federal Ministry of New and Renewable Energy for solar thermal systems, through mainstream banking channels is superior in intent and outcome compared to the capital subsidy as currently offered for solar PV systems, routed through government controlled delivery channels. The interest subsidy enhances innovation, improves service delivery and expands the range of product available to consumers enjoying a wide range of endowments, thus leading to more inclusive development. The simple monopoly model developed by Atkinson [Atkinson AB. Capabilities, exclusion and the supply of goods. In: Basu K, Pattanaik P, Suzumura K, editor, Choice, Welfare and Development. Oxford University Press; 1995] is applied to the context of solar home systems to demonstrate price reduction and choice expansion in a liberalized market, facilitated by an interest subsidy scheme.

© 2009 Elsevier Ltd. All rights reserved.

Contents

1. Introduction

Development is the enlargement of people's choices.[2] Development policy that restricts choice is regressive. Governments might choose to subsidize certain sections of consumers for political reasons or as a part of development strategy. In most developing countries, politics often affect the continuance, distribution, geographic expansion and eventual termination, if at all, of subsidies, [1]. Although the discounted prices increase the demand for normal goods, they could lead to supply-side distortions, restricting people's choices. Inappropriately designed subsidy programs could, thus, end up being counterproductive.

The penetration of renewable energy technologies is impeded by sub-optimal pricing for power, continuing cross-subsidies [2] and retarded power sector reform, attributed mainly to the instability of policy-makers, poor overall acceptance of the reforms, slow adaptation and poor transition management, [3]. Rationalizing power tariffs is projected to encourage energy conservation behavior and investments in energy efficiency while favoring distributed generation, [4]. Others argue that in addition to streamlining the power sector, a national renewable energy policy is a vital prerequisite to translate customer choice into a larger market share for non-conventional energy technologies such as solar photovoltaic (PV) and thermal applications, [5].

☆ Disclaimer: The views expressed in this article are of the author himself and do not necessarily reflect those of any organization.

* Tel.: +91 821 2547; fax: +91 821 2547 553.
E-mail address: sunderasan@yahoo.com.

1 http://www.verdurous.in.

2 The First UNDP – Human Development Report, 1990, http://hdr.undp.org/en/reports/global/hdr1990/.

1364-0321/$ – see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.rser.2009.06.005

Worse, misplaced policy within the ambit of promotional measures for renewable energy, compounded by bureaucratic entrenchment could retard market evolution.

2. Donor experiences with market making programs

Grameen Shakti, the energy service company floated by Grameen Bank of Bangladesh has exploited the accumulated business acumen, the branch network and existing client base to create a successful solar energy business. Grameen Shakti has accessed refinance and grants from the World Bank's Rural Electrification and Renewable Energy Development Project through the Infrastructure Development Company.[3] The grants help bring down the first costs while the refinance provides requisite liquidity to expand the availability of micro-credit for the solar energy systems.

Rated "satisfactory", the highest rank awarded, by the Independent Evaluation Group of the World Bank [6], the ongoing Renewable Energy for Rural Economic Development in Sri Lanka,[4] provides refinance and a co-financing grant to privately owned financial intermediaries, who in turn, extend retail credit for the procurement of solar energy systems. The program prescribes technical specifications for components such as photovoltaic modules, batteries, etc., while vendors are at liberty to configure systems to cater to market demand.

Alternative schemes to encourage intermediaries to extend credit in rural areas include grants and default guarantees, usually extended by third parties or donor agencies as those provided by the Global Environment Facility (GEF)/International Finance Corporation (IFC) under the Photovoltaic Market Transformation Initiative (PVMTI). The default offset is viewed as a risk mitigation measure, and thus helps to expand the availability of credit for the procurement of solar energy systems.

The government of India provides subsidies to enhance the competitiveness of solar PV and solar thermal systems, which have, over the years, conditioned the supply-side of the industry.[5] For instance, the Indian Renewable Energy Development Agency (IREDA) has employed the leasing model, wherein financial intermediaries commonly referred to as non-banking finance companies, are provided with long-term, low-cost refinance for leased solar energy equipment. However, it is observed that some of the intermediaries involved availed of the fiscal benefits from owning the renewable energy devices, and of the low-cost refinance but avoided extending credit for the projected tenure. Owing to the complex processes and documentation involved, equipment has been sold with a small upfront discount in lieu of the long-term soft loan. Lack of end-user credit has, as a result, curtailed market growth.

To achieve a measurable impact on market growth and to reach a diverse cross-section of users, retail financing terms need to be flexible. Private sector financial intermediaries functioning within an unbiased competitive environment are most suited to offering innovative product-credit packages. In general, subsidies should be phased out simultaneous with strengthening of the institutions involved. The framework of incentives for the participants should be developed with a view to ensuring sustainability of the value chain so as to ensure prompt post-installation service and help service providers benefit from resulting network effects. This paper analyzes two schemes: the capital subsidy provided to encourage the deployment of solar PV systems ('solar home systems: SHS'), and the interest subsidy provided to support the dissemination of solar water heating systems (SWH). A characteristic feature of the electricity sector in India is the unreliability [7] and power cuts are an acknowledged "way of life", with the demand-supply gap progressively widening, [8]. Consequently, unlike in other developing countries where solar PV systems generally make their way into unelectrified homes, in India, such systems are acquired in large measure by households with access to the grid. Similarly, the SWH are employed to reduce dependence on grid supplied electricity and hence, there is a substantial overlap in the target markets for the solar PV lighting systems and solar water heaters in smaller towns and peri-urban areas. In addition, this paper makes a mention of the channels used to route such subsidies while exploring the reasons for the outstanding success of one scheme relative to the other.

3. Solar photovoltaic home lighting systems

Solar Photovoltaic technology is considered to be ideally suited to illuminate and pump water at remote locations and dispersed settlements, where extension of the utility grid or making other alternatives available could be technically infeasible or economically unviable, [9]. However, low customer density in a given service territory makes sales, installation, service and payment collection expensive and difficult, giving rise to transaction costs which are in the order of 30% of the total system costs, [10]. This reduces affordability, undermines sustainability of systems and diminishes the effect of the progressive reduction in PV system prices. Further, provision of credit in remote and rural areas is often perceived to be expensive, even unviable, owing to high collection costs and on account of limited collateral security that can be offered in the context. In contrast, the Grameen experience and the resulting micro-credit revolution have illustrated that availability of credit provides a sustained improvement in the quality of life. Ostensibly, creation of viable and sustainable sources of consumer finance is vital for the sustainability of renewable energy projects, [11].The Indian SPV Demonstration and Utilization Program is implemented through the state nodal agencies of the federal Ministry of New and Renewable Energy[6] and through select non-governmental organizations. The program has been operational since 1993–1994 and serves to provide subsidies to facilitate the purchase/installation of solar home systems, street lighting systems, and similar SPV applications. The Ministry has laid down detailed specifications of all SPV lighting and other systems and prototypes are tested and approved by authorized test centers. The five approved models are: 18Wp PV module with one 9 W compact fluorescent lamp (cfl), 37Wp PV module with two 9 W cfl or one 9 W cfl and a fan, 74Wp PV module with four 9 W cfl or two 9 W cfl and a fan/TV, [12]. Subsequently, the capital subsidy payable on the 74Wp model has been curtailed to the level of the 37Wp model, lowering the incentive thereon. Further, the Ministry has imposed price ceilings on systems, to be packaged with comprehensive maintenance contracts for 2, 5 or 10 years.

Over the tenure of the country's 10th five-year plan 2002–2003 through 2006–2007, against a target of 202,000 solar home systems (SHS), the program has helped deploy a total of 107,904 systems, corresponding to a 53% accomplishment of targets. The budget estimates and actual achievement of targets for each of the years, as reported by the Ministry are as laid out in Table 1.

4. Solar thermal water heating systems

Solar thermal water heating systems (SWH) replace electric or LPG geysers in urban settings and firewood or other fuels, appliances and techniques used to heat water in rural areas. The reduced consumption of such fuels as firewood, coal, furnace oil etc., contributes

[3] www.idcol.org.

[4] www.energyservices.lk.

[5] India is not isolated in this regard. Spurred by low power prices, South Africa's aggregate demand for energy is slated to double in a decade. Observing that close to 20–30% of electricity use is dedicated to heating water, Eskom, the national utility has initiated "aggressive promotion of solar water heating systems" through a Rand 2 billion subsidy program, [21].

[6] http://mnre.gov.in.

Table 1
Year wise targets and installations of SPV systems.

Year	2002–2003		2003–2004		2004–2005		2005–2006		2006–2007	
INR (crore)	53.00	41.24	37.00	28.65	23.00	12.12	25.00	23.55	29.50	47.66
SHS (no.)	50000	28430	50000	11870	0	34844	42000	9727	60000	23033

Table 2
Year wise targets and installations of SWH systems.

Year	2002–2003		2003–2004		2004–2005		2005–2006		2006–2007	
INR (crore)	11.00	9.73	12.00	9.90	14.00	6.91	50.00	24.89	45.75	13.23
SWH (area, m^2)	50,000	45,000	55,000	0	100,000	150,000	400,000	400,000	400,000	400,000

to mitigation of carbon-dioxide emission and reduction in degradation of the environment. SWH have healthy monetary paybacks and with an LPG or electrical backup for non-sunny days, can provide heated water round the year. Large scale deployment of the SWH also helps reduce peak load demand for the electric utility, [13].

The Ministry has encouraged a range of financial intermediaries (FI), including state-owned and private sector banks to participate in the low-interest ("soft loan") scheme to extend loans of up to 5 years' tenure, not exceeding 85% of the project cost, at subsidized rates of interest. The Ministry compensates the implementing FI for the difference between prevailing commercial interest rates and the subsidized rates on offer. The subsidized rate of interest is available to domestic end-users, commercial establishments, cooperative societies and real estate developers, [14]. Key attributes of the Solar Thermal Energy Program are: the absence of upper limits to the sizing of systems and the inclusion of the evacuated tubular collectors (ETC) under the soft loan scheme.

In sharp contrast to the figures reported above in the context of solar home systems, over the same period, against a target of 1,005,000 m^2 of collector area, the program has contributed to the deployment of a total of 995,000 m^2, corresponding to a 99% accomplishment of targets. The budget estimates and actual achievement of targets for each of the past five years, as reported by the Ministry are as laid out in Table 2.

5. Quantitative equivalence of the two subsidy schemes

Chandrasekar and Kandpal Tara [15] have computed the effective capital cost of solar energy technologies consequent to the fiscal and financial incentives provided by the government and have established indifference levels for various input parameters. For instance, they demonstrate that the provision of a low interest loan ("soft loan") at 2% annual rate of interest would be equivalent to a capital subsidy of 14.32% from the end-user's perspective. This paper views subsidy provision from the government's perspective and identifies the indifference level between allocation towards the capital subsidy and the interest subsidy. Next, the effective cost to the end-user is computed using a larger set of input parameters to establish the equivalence between the two schemes. The paper then goes on to discuss the restrictions imposed by the capital subsidy program and the enlargement of choices through the implementation of the interest subsidy scheme.

C_o	Capital cost of system (currency units)	I_t	Interest amount payable at time t (currency units)
I_b	Interest rate set by the commercial bank (%)	P_t	Amount outstanding at time t (currency units)
I_s	Interest rate subsidy buydown offered by the government as promotional incentive (%)	R_t	Principal amount repaid in time t (currency units)
I_g	Discount rate for government funds such that $I_g < I_b$ (%)	C_{is}	Discounted value of the interest subsidy paid by the government (currency units)
I_m	Market Interest rate paid by borrower to access the net-of-subsidy amounts such that $I_g < I_b < I_m$ (%)	CF_{is}	Periodic payments by the government towards interest subsidy on the loan (Currency units)
I_w	Weighted average interest rate paid by borrower such that $I_b < I_w < I_m$ (%)	f_{cs}	Fraction of capital cost paid as subsidy (%)
F_{cs}	Portion of capital cost paid as subsidy (currency units)	f_{sl}	Fraction of capital cost available as soft loan (%)
PMT_t	Periodic payments including principal and interest on outstanding balance (currency units)	CF_w	Periodic payments by the end-user towards repayment of the loan (currency units)
		C_w	Discounted value of end-user loan service (currency units)

As shown in result 1 of annex 1, purely basing on the direct subsidy expenditure per system, the government is indifferent between offering an interest subsidy to lower the rate for the borrower by I_s and providing a capital subsidy F_s equal to $C_{is,}$ where,

$$C_{is} = \sum_{i=1}^{n} \frac{(CF_{is})}{(1 + i_g)^t}$$

We now proceed to establish the equivalence from the end-user's perspective. Even as a capital subsidy of F_{cs} is made available, the end-user is required to mobilize the net-of-subsidy amount (C_o–F_{cs}). This is mobilized at commercial rates prevailing in the markets, I_m, commensurate with the borrower's risk class. In the scenario where an interest subsidy is provided, the weighted average cost of the loan, I_w is given by: $I_w = (I_b - I_s) f_{sl} + I_m(1 - f_{sl})$

The annuities payable by the end-user are computed and discounted at the prevailing market rate to arrive at the equivalent upfront payment, as perceived by him/her.

$$C_w = \sum_{i=1}^{n} \frac{(CF_w)}{(1 + i_m)^t}$$
$$= F_{cs} \text{ (to establish the indifference level)}$$

It is now possible for us to compute the indifference values for the government and simultaneously for the end-users, for a range of input values.

For the input parameters provided in Table 3 above, the interest buy down is 8.21% equivalent to a capital subsidy of INR 4615 or about 23% of the capital cost. The net-of-subsidy amounts are

Table 3
Input parameters to compute the indifference between capital and interest subsidies.

System cost	INR 20,000 (~US$ 500)
Bank rate of interest	12%
Discount rate for government funds	6%
Market rate for end-user from informal and semi-formal sources	16%
Proportion of soft loan available	85%
Tenure of the loan	5 years

mobilized by the end-user at the prevailing market rates. This paper argues that the similarity among the capital and interest subsidy schemes ends here.

6. Qualitative divergence of the two subsidy schemes

1. The principal difference between the schemes under discussion is the mode of delivery. The capital subsidy is delivered through nodal agencies and other qualified non-governmental organizations, while the interest subsidy is routed through the existing network of commercial banks and financial intermediaries. The not so insignificant indirect cost of routing the capital subsidy through parallel bureaucratic channels is not reflected in the computation above. In certain situations, as observed by industry watchers, subsidy management begins to justify the existence of the bureaucracy and reciprocally, enhances such entrenchment, simultaneously creating rent seeking opportunities.
2. The subsidy budgets are determined at the federal level and are drilled down to the state level implementing agencies by prescribing numbers of subsidy-eligible systems. The implementing agencies, further allocate, rather arbitrarily, quotas to select vendors. This leads to the creation of a supply-side dynamic where oligopolists market their wares in partially overlapping or non-overlapping intrastate markets, with fixed prices and identical product. In short, the oligopolists, almost inadvertently, end up acting as a monopolist.
3. Further, in order to standardize qualification for the subsidy, rigid eligibility criteria and technical specifications have been drawn up for the systems. This, by itself, curtails choice. For instance, in the above list of specified systems, a consumer is not permitted to acquire a 37Wp system capable of powering one lamp and one fan and to combine it with the 18Wp system to power an additional lamp. By restricting the modular expansion or contraction, the pre-designed quantity packages restrict the choices available to the end-users.
4. The one differentiator that could have emerged in this set-up is the quality of post-installation service, which is a function of the rigor of enforcement by the implementing agency. It has been observed on several occasions, rural service providers scale down operations or completely go out of business upon the termination of subsidy programs, indicating that their businesses are only as sustainable as the subsidies themselves. The systems installed under the erstwhile programs, thus suffer from a lack of professional service provision for the remaining portion of their technical lives. The net-of-subsidy price is low enough to eliminate all economic profits on non-subsidized systems, and hence deters entry and supply of systems with different technical specifications or the set up service networks.
5. In contrast, the interest subsidy scheme on offer through commercial banks is not constrained by price, installation size or single borrower limits. The banks have demonstrated keen interest in offering the soft loans to promote the installation of the SWH. The evaluation criteria do not prevent the end-user from choosing a 5000 lpd (litre-per-day) SWH over a 100 lpd installation. Further, the systems are installed and maintained by vendors whose systems and components are certified by the Bureau of Indian Standards (BIS).
6. Unlike the SHS vendors, the SWH vendors have aggressively invested in building brands and reputations through prompt and disciplined post-installation service. The quality of the system and the service, therefore, effectively sets vendors apart, who eventually earn premiums on such brand equity. This is not possible in a price constrained environment. In fact, at the most elementary level, policy-makers should realize that price ceilings lead to shortages: in case of the system-service package, the post sale service is in acute short supply.
7. Further, the SWH vendors have also marketed evacuated tubular collectors (ETC), which represents a lower-priced technology variant, compared to the traditional flat-plate collectors. Being static in definition, the specifications for SHS do not allow for the inclusion of newer technologies viz., LED clusters to supplement the compact fluorescent lamps – as such designs would not be eligible to avail of the capital subsidy.

7. Choice and inclusive development

Arrow [16] asserts that a rational individual would choose an opportunity which helps to achieve the highest level of utility, and that adding new opportunities cannot worsen the choice. Irrespective of whether the additional element is better than the originally chosen one, giving an individual more choice is *per se* valuable. In practical terms, the choice need not pertain to a range of goods: it would equally apply to quantities and qualities of a good supplied. Packaging goods in discrete quantities and pre-designed price-quality combinations adversely affects the poor. Quality standards prescribed by regulatory authorities could, thus, put goods out of reach of certain sections of society. Economic progress leads to the invention of higher quality products and this may include or exclude a larger proportion of the poor depending on concomitant changes in effective unit costs and price levels within the existing industry structure.

8. Subsidy policy and the range of choices

In a market with a single quality of a good, firms compete exclusively through price strategies. In the SHS market, the quality and price are exogenously determined and hence the vendors behave as a cartel and barely compete. Where implementing agency oversight and enforcement is weak, such service support (and quality of the installation itself) is overlooked. The failure of a monopolist—or oligopolists acting in concert as in this case—to supply all the market and the prospect of a positive economic profit would attract entry. However, if the monopolist produces a superior product, as in the case of the specified solar home systems, while an entrant chooses to offer a product with a lower specification, at a lower price, the profit-maximizing response from the erstwhile monopolist would be to lower the price charged, [17].

The level of profit for a monopolist supplying a commodity at price p, with a constant marginal cost c, per unit and a fixed cost of production k is given by

$$\prod = (p-c)\left[1-F\left(\frac{p}{\lambda}\right)\right]-k$$

where Atkinson [17] defines λ as a person's productivity-related, wage-influencing parameter. Further, $\lambda_{\max}$ and $p_{\max}$ are respectively, the quality and price of a superior (say prescribed technical specification) product and λ and p are the quality and price of a relative lower specification product, the market is segmented into consumers who can afford the superior product, those who can afford only the inferior product and those excluded. The pricing of the lower quality products by the same vendor needs to account for the revenue loss from customers who switch from the superior product. The profit from offering the two products is given by

$$\prod = (p-c)[1-F(w*)] + (\rho-\gamma)[1-F(w**)] - k - k_{\max}$$

where $\rho = p_{\max} - p$; $\gamma = c_{\max} - c$ and w^* is the threshold exclusion wage while w^{**} empowers the purchase of the superior product. Since the two products in question are not perfect substitutes—

though they may essentially perform the same function of lighting the household—the pricing strategy for the inferior product is independent of the superior product.

Suppose the incumbent supplies the superior product as prescribed under the capital subsidy scheme, a potential entrant could sell an inferior product at a lower price. An interest subsidy scheme can facilitate the purchase of such a system while the capital subsidy scheme accompanied by rigid technical specifications excludes it. The arguments posed by Atkinson [17] for two discrete commodity quality stipulations can thus be extended to cover a large number of variants assembled through mixing and matching quality certified components, maximizing choice and including a larger proportion of the population. Additionally, we relax the assumption relating to product indivisibility, to reflect the possibility of numerous combinations of system components.

Where the incumbent has the option to adjust price, a reduction in price by surrendering a portion of the monopoly rents is likely, in an attempt to ward off competition. If the rival SHS is preferred to non-purchase, the entry leads to widening the range of systems and to reducing the income necessary to purchase each of the models available. Prices and availability of goods are determined endogenously by the decisions of suppliers faced with specified market conditions. Vendors supplying product under inflexible and exogenously imposed price-ceilings would have an incentive to compromise on the service component of the product-service package. As for the end-users, the monopoly price may exclude some customers at the lower rungs of society from the market and hence deprive them of the product.

If both, the superior and the inferior product are brought to the market by the monopolist, and given the assumption that the profit from the supply of both products is greater than that earned by supplying either product alone, the price of the inferior product as defined by Atkinson [17] is:

$$p = \frac{1}{2}(\lambda w_{\max} + c)$$

The price for the said inferior product when offered by the entrant is given by:

$$p = \frac{1}{2}\left(\frac{\lambda\, p_{\max}}{\lambda_{\max}} + c\right)$$

which is lower by

$$\Delta p = \frac{1}{2}(\lambda w_{\max} + c) = \frac{1}{2}\left(\frac{\lambda\, p_{\max}}{\lambda_{\max}} + c\right) = \frac{1}{2}\lambda\left(w_{\max} - \frac{p_{\max}}{\lambda_{\max}}\right)$$

If the maximum wage endowment in the target market, $w_{\max}$, and price per unit of quality for the superior commodity, $p_{\max}/\lambda_{\max}$, remain constant, the price reduction through liberalization of the market is a function of the quality chosen for the inferior product. By relaxing the indivisibility assumption, we are able to fashion multiple variants at corresponding price points.

9. Sector, segment and market neutrality

The European roof-top market has grown on the back of low-cost finance and high feed-in tariffs offered and have helped advance an environmentally benign image for the power sector, especially in countries like Germany and Spain. Convergence with the utility grid in Japan has been driven by similarly structured subsidy programs. In urban and sub-urban India, the PV systems would be filling the gap in the power supplied by the utility grid and would compete against other alternatives available in the urban context, viz., the ubiquitous diesel generators or inverter-based systems which draw power from the grid and typically use automotive batteries for storage. Most computers are connected through uninterruptible power supply systems (UPS), to bridge the gap during grid outages.

A Diesel generator of equivalent capacity has a life cycle cost of almost twice that of a PV system, in some situations [18,19] have worked on the economic viability of the stand-alone PV system as compared to the Diesel-powered system and, given Indian operational parameters, have arrived at energy demand range of 15 kWh/day (worst case) to 68 kWh/day (best case) where PV-powered systems are cost competitive. Along similar lines, Hansen and Bower [20], opine that electricity planners have focused attention on lowering electricity costs at generation sites, while transmission and distribution losses and thefts have taken their toll. Further, subsidized tariffs on grid-supplied power reduce the incentive to look for alternatives. They believe that small scale generation technologies with power ranges as low as 5 kW (indicative range) are now in a position to compete economically with grid connected central generating capacity. This evolution in economics of alternatives opens up a world of possibilities for the production of electricity close to the point of consumption, thus reducing both technical and non-technical losses.

A rapid increase in volumes from a relatively "easy" market ("low hanging fruit") would help reduce prices for the market as a whole ("scale effects"). Additionally, higher installation density and a critical mass of systems help offset the higher costs of providing energy services in dispersed expanses ("network effects"). Appropriate banking channels could be identified to route the interest subsidy, as for instance, through rural branches of commercial banks, cooperative banks etc. The policy intended for the promotion of a certain technology should be neutral to territorial demarcations, applications and classes of end-users.

10. Conclusions

Financing mechanisms should be non-distortionary, inexpensive to administer and competitively neutral, enhancing allocative efficiency and not benefiting a few firms at the expense of others. Liberalized entry and competition encourage innovation and lead firms to generating a wealth of service, price and quality options to reach the target markets. The interest subsidy routed through banking channels is a superior option as it does not depend on quota or geographic allocation and merely requires that quality marked components be employed. Since the soft loan is linked to the capital cost of the installation, prepackaged system sizes and exogenously determined prices are not prerequisites. A competitive market enables innovation and the creation of brand equity, multiple price points and a range of robustly engineered quality options, while ensuring prompt and disciplined maintenance service for the systems. The end-users learn to discern product and service quality, over time. The bureaucratic channels presently intent on controlling the distribution of capital subsidy could be put to better use in creating awareness among the target population and in encouraging vendors to use quality certified components.

With the enlargement of the interest subsidy scheme, the systems, rather than the end-users are required to meet eligibility criteria. The consumer is at complete liberty to choose the vendor, the lender, the combination of sub-systems in the quality range between $\lambda_{\max}$ and λ and a price point between p and $p_{\max}$, commensurate with his/her own endowment.

Appendix A. Annex 1

$$PMT_t = \frac{C_o[i(1+i_b)^n]}{[(1+i_b)^n - 1]}$$

$$I_t = I_b P_{(t-1)}$$

$$R_t = PMT_t - I_t$$

$$P_t = P_{t-1} - R_t$$

$$CF_{is} = I_t P_t$$

Interest subsidy paid during the tenure of the loan is discounted at the rate of return on alternative use of government funds I_g

$$C_{is} = \sum_{i=1}^{n} \frac{(CF_{is})}{(1 + i_g)^t}$$

The equivalent capital subsidy as a proportion of system cost is given by C_{is}/C_o

The government is therefore indifferent between offering an interest subsidy to lower the rate paid by the borrower by I_s or a capital subsidy, F_s equal to C_{is}.

Result 1.

Capital subsidy provided = F_s

Net-of-subsidy amount to be mobilized = $C_o\ (1 - f_s)$

Result 2.

$$C_w = \sum_{i=1}^{n} \frac{(CF_w)}{(1 + i_m)^t} = F_{cs}$$

References

[1] Clarke GRG, Wallsten SJ. Universal service: Empirical evidence on the provision of infrastructure services to rural and poor urban consumers. In: Brook Penelope J, Irwin, Timothy C, editors. Infrastructure for Poor People. The World Bank; 2003.
[2] Chattopadhyay P. Testing viability of cross subsidy using time-variant price elasticities of industrial demand for electricity: indian experience. Energy Policy 2007;35(1):487–96.
[3] Bhattacharyya SC. Power sector reform in South Asia: why slow and limited so far? Energy Policy 2007;35(1):317–32.
[4] Pearce JM, Harris PJ. Reducing greenhouse gas emissions by inducing energy conservation and distributed generation from elimination of electric utility customer charges. Energy Policy 2007;35(12):6514–25.
[5] Rader NA, ShortIII WP. Competitive retail markets: tenuous ground for renewable energy. Electricity J 1998;11(3):72–80.
[6] World Bank, New Renewable Energy: A Review of the World Bank's Assistance, Independent Evaluation Group, 2006.
[7] Makhijani A, India Should Choose Iran, Not US, www.rediff.com, 28 December, 2005.
[8] Economist, The. India's Electricity Reforms: Underpowering, 22nd September 2005.
[9] Carlos, Ciscar J, Photovoltaic Technology and Rural Electrifcation in Developing Countries: The Socio-economic Dimension'', 1997 IPTS Report No. 19, www.jrc.es/iptsreport/vol19/english/ENE1E196.htm.
[10] Yang H, Wang H, Yu H, Xi J, Cui R, Chen G. Status of photovoltaic industry in China. Energy Policy 2003;703–7.
[11] GEF Results from the GEF Climate Change Program - Evaluation Report # 1-02, Monitoring and Evaluation Unit, Global Environment Facility, 2001.
[12] MNRE (2006), Annual Report of the Ministry of New and Renewable Energy, Government of India, for the year 2005–2006.
[13] Srinivasan S. Transforming solar thermal: policy support for the evolving solar water heating industry. Refocus 2006;46–9.
[14] MNRE (2006). Annual Report of the Ministry of New and Renewable Energy, 2005–2006.
[15] Chandrasekar B, Kandpal Tara C. Effect of financial and fiscal incentives on the effective capital cost of solar energy technologies to the user. Solar Energy 2005;78:147–56.
[16] Arrow, Kenneth J. A note on freedom and flexibility. In: Basu K, Pattanaik P, Suzumura K, editors. Choice, Welfare and Development. Oxford University Press; 1995.
[17] Atkinson AB. Capabilities, exclusion and the supply of goods. In: Basu K, Pattanaik P, Suzumura K, editors. Choice, Welfare and Development. Oxford University Press; 1995.
[18] Taylor R, Abulfotuh F. Photovoltaic electricity in Egypt, renewables for sustainable village power, project brief, Department of Energy, USA. NREL 1997.
[19] Kolhe M, Kolhe S, Joshi JC. Economic viability of stand-alone solar photovoltaic system in comparison with diesel-powered system for India. Energy Economics 2002;24:155–65.
[20] Hansen CJ, Bower J. The political economy of electricity reform: a case study in gujarat, India. Oxford Institute for Energy Studies 2003;47.
[21] Osterkorn M. Solar Thermal to Score in SA? Renewable Energy Focus 2007;29–30.

Dr. **Srinivasan Sunderasan** is a Life Member of the Solar Energy Society of India, a Member of the Institution of Engineers, India, and an Economist with Verdurous Solutions (www.verdurous.in), an investment advisory and management consultancy focused on the ''green'' space. He has been awarded a Doctoral Degree in Business Economics by the University of Vienna, Austria, for his work on Mainstreaming Renewable Energy. His first degree is in Civil Engineering and has been awarded a Masters' Degree in Business Administration by King Fahd University of Petroleum & Minerals, Dhahran, Saudi Arabia. He has also completed a graduate diploma program in Environmental Law at the National Law School University of India, Bangalore.